# PATENT SPECIFICATION

**684,052**

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COMPLETE SPECIFICATION

## Improvements in and relating to Magnetic Filtration Systems

I, HEINRICH SPODIG, a German National, of 2, Kirschbaumweg, Dortmund-Wambel, Germany, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates generally to magnetic filtration systems, and particularly to a magnetic filtration system including a permanent magnet for attracting and collecting magnetizable particles.

Magnetic filtration systems of the permanent magnet type are known; they are used for separating, attracting and filtering ferromagnetic solid particles from easily movable solids such as granular materials and the like, or from fluids such as gaseous or vaporous media or liquids, particularly machine oil or lubricating oil. Such filters are provided for example in a suitable portion of the pressure conduit, or of the return conduit of the oil such as a lubricating oil circulating through a metal working machine. The filter is used to attract the dust, filing or metal particles which are produced by the working of the metal. In view of the abrasive effect of such metallic particles they frequently cause extensive damage to sliding surfaces or other relatively movable machine parts to be lubricated. For the same reasons it is also customary to attach such filters to the walls of the gear housing of automobiles and machines, to lubricating oil tubs, crank cases and the like to remove abrasive particles from the oil.

Thus it has been proposed to provide a simple rod or horse shoe magnet which projects into the medium to be cleaned. The ferromagnetic particles are attracted to the poles of the magnet to form a beard-like mass, but these accumulations are easily removed by the medium flowing past the magnet pole. Thus the particles are swept again into the medium and since they are now magnetized they cling together and cause still greater destruction in the machine.

For the same purpose it has been proposed to use magnet systems comprising permanent magnets and ferromagnetic soft iron pieces having an air gap across which a magnetic field is developed. However, the action of a magnetic field developed in such an air gap is comparatively weak so that only few ferromagnetic particles can be collected in the comparatively small space of the air gap. Furthermore, stray magnetic fields are formed even outside the air gap which will attract ferromagnetic particles that will assume a bulge-like shape. The stray magnetic fields which are farthest removed from the air gap will only weakly attract the particles and in this case the ferromagnetic accumulations of filtered particles which project into the flowing medium (such as circulating lubricating oil) are swept again into the medium as a conglomeration of particles which then again exercise their detrimental action. Besides these detrimental drawbacks most of the known magnet systems have uncontrollable magnetic stray fields originating from various places of their surfaces. These stray fields will also attract ferromagnetic particles which, being easily removable, will later be swept away and contaminate the circulating fluid thus causing further damage.

It is accordingly an object of the invention to provide an improved magnet system for attracting and removing ferromagnetic particles from a fluid such as oil which avoids one or more of the disadvantages of the prior art.

A further object of the invention is to provide a permanent magnet system for the purposes specified which has a

great attraction for ferromagnetic particles and which will substantially prevent such particles from being washed away again by the medium to be cleaned.

Another object of the invention is to provide a magnet system which has substantially no uncontrollable stray magnetic fields and which has a space suitable for collecting a large number of ferromagnetic particles.

According to the present invention, there is provided a magnetic filtration system for attracting magnetizable particles which comprises a pair of permanent magnets, each having a north and a south pole, an intermediate plate, and two outer plates of soft magnetic material, said intermediate plate being disposed between identical poles of said magnets and said outer plates being disposed adjacent to the remaining poles of said magnets and extending beyond said intermediate plate and said magnets, whereby substantially no magnetic lines of forces originate from the outer surfaces of said outer plates, while the magnetic field from said intermediate plate is very strong.

The invention will be described further by way of example, with reference to the accompanying drawings in which:—

Figs. 1 to 4 are cross-sectional views of permanent magnets which have the drawbacks described hereinbefore;

Figs. 5 to 7 are cross-sectional views of permanent magnet systems which illustrate a novel magnetic effect on which the present invention is based; and

Figs. 8 to 17 are cross-sectional views of permanent magnet systems embodying the present invention.

Referring to the drawing, there is shown in Fig. 1 a rod-shaped permanent magnet 1 having a north pole N and a south pole S. A pair of ferromagnetic soft iron plates or pole pieces 3 and 2 which may be of circular shape are disposed about the poles of the magnet. Consequently, a magnetic field is developed having an N pole and an S pole on the plates 2 and 3. The soft iron plates 2 and 3 may also have a rectangular or oval outline or they may each have the shape of a hollow semi-sphere as shown in Fig. 3. Alternatively, in order to vary the magnetic stray effect and to provide for a larger volume for collecting ferromagnetic particles the air gap formed by the edges of the plates 2 and 3 may be widened or outwardly flared as illustrated in Figs. 2 and 4.

However, the magnetic effect of the magnets of Figs. 1 to 4 is the same, the magnetic field only being effective at the outer edge of the magnet system and having all the detrimental effects already described in view of the detrimental stray effect of the air gap. These filters have not been described heretofore but it is believed that their mode of operation is well understood in view of the present state of the art. These magnets further show uncontrollable magnetic stray fields at the surface of the magnet (indicated in the drawing) which increase their detrimental effect.

Fig. 5 illustrates a magnet system including two permanent magnets 1 and 2. A soft iron intermediate plate 3 is disposed between the magnets 1 and 2, and a pair of outer soft iron plates 4 and 5 cover the outer or free poles of the magnets. Plates 3, 4 and 5 may be of circular outline and of equal diameter. Preferably the S poles of the permanent magnets 1 and 2 are secured to the intermediate plate 3 which forms a common S pole at the outer edge while the two outer plates 4 and 5 are secured to or in contact with the N poles of the two permanent magnets 1, 2 so that an N pole is formed at the outer edge of each of the plates 4 and 5. Accordingly, the magnetic lines of force of the S pole or intermediate plate 3 are twice as numerous or strong as the magnetic lines of force from the two N poles or outer plates 4 and 5. The intermediate plate 3 is preferably made thicker than the outer plates to accommodate the magnetic fields of the two permanent magnets 1 and 2. This arrangement permits the provision of a magnetic field which is twice as strong and which is centered toward the middle of the outer magnet system. This effect already is advantageous. However, a magnetic field is still developed between the outer edges of the system across two air gaps with the resulting well known drawbacks. Furthermore, the detrimental, uncontrollable stray magnetic fields at the outer surface of the magnetic system have not been avoided.

If the diameter of the intermediate plate 3 is increased beyond that of the outer plates 4 and 5 as shown in Fig. 6, the magnetic lines of force from the periphery of the enlarged intermediate plate 3 become less numerous or weaker. However, the magnetism of the outer plates 4 and 5 remains the same. The detrimental uncontrollable magnetic fields have not disappeared. If the diameter of the intermediate plate 3 is further increased, the lines of force from the S pole or intermediate plate 3 become less and less until they are zero as shown in Fig. 7. The lines of force from the N pole or outer plates 4 and 5, however,

remain substantially at the same high value.

This unexpected magnetic effect is novel and has not previously been described. It is of no practical importance for the purpose of the invention but serves to clarify the magnetic theory developed in accordance with the invention.

However, if the intermediate plate 3 is reduced in diameter toward the interior of the magnetic system as shown in Fig. 8, the magnetic lines of force of the S pole along the periphery of the intermediate plate 3 are increased in direct ratio to the reduction of the diameter. On the other hand, the lines of force from the N poles of the outer plates 4 and 5 disappear gradually. If the S pole or intermediate plate 3 is further reduced in diameter (Fig. 9) a further increase of its lines of force takes place while the lines of force from the outer plates are reduced to zero. The outer plates 4 and 5 have thus become non-magnetic, and consequently, uncontrollable stray fields at the outer surfaces of the outer plates are no longer present. The reduction of the diameter of the intermediate plate 3 may be continued until its diameter equals that of the permanent magnets 1 and 2 as illustrated in Fig. 10. This unexpected magnetic effect has not previously been described and is of great importance for the purpose of the invention. It serves as the basis for the magnetic filtration system of the invention for attracting and collecting ferromagnetic particles.

A magnetic filtration system according to the invention, when arranged to separate and attract ferromagnetic particles from a fluid medium, operates as follows. The particles are first attracted by the inner magnetic field of the system to the points having the largest number of magnetic lines of force between the mid-portion of permanent magnet 1 and that of permanent magnet 2, Fig. 11. The ferromagnetic particles are strongly attracted to these points; gradually a thicker layer builds up (Fig. 12) until the particles assume the shape of Fig. 13 in accordance with the above described magnet theory. The attracted ferromagnetic particles have the tendency, as the filter process proceeds, to orientate themselves in the interior of the system toward the outer plates, 4, 5 where they slowly form a magnetic short circuit. As the filtering process proceeds further, the stronger centre field gradually attracts more and more particles, which orientate themselves toward the outer plates.

This process continues until the entire space limited by the outer plates is filled with ferromagnetic particles, Fig. 13. This space should be made as large as possible. The magnetic system is short-circuited after this collector space is filled with ferromagnetic particles. This mode of operation of the magnetic system of the invention may be called a strong magnetic suction effect. The collected ferromagnetic particles are strongly attracted by the magnetic circuit but do not form magnetic stray fields which project into the flowing medium, and therefore bulge-like or beard-like accumulations of ferromagnetic particles which may be easily swept away, are not formed. The outer plates 4, 5 may have the shape of a hollow semi-sphere as shown in Fig. 17, the operation of the system remaining unchanged. This construction is particularly suitable for use in milling installations, e.g. ball mills to collect ferromagnetic dust accruing during pulverisation. Furthermore, the outer plates may have outwardly bent or flared edges, as shown in Fig. 16, so that a further increase of the collector space for the ferromagnetic particles to be attracted is obtained. However, the outer plates may also be inwardly tapered. Furthermore, it is possible to cover the magnet system which is open on all sides by a cylindrical, perforated non-magnetic cover 6 of sheet material which will pass the ferromagnetic particles and which may be secured to the outer plates 4, 5 as shown in Fig. 14. It is also possible to arrange several magnetic filtration systems in accordance with the invention. For example, the systems may be disposed in a suitable filter housing or they may be used as a filter for circulating oil. Alternatively, such magnet systems in accordance with the invention may be fixed to the drainplugs used for draining oil from gear housings, oil containers and the like. In this case the magnetic filtration system may be secured to the drainplug or may be disposed within a suitable bore of the plug. To this end the embodiment of Fig. 15 may be used with advantage where plates 4, 5 are provided with suitable openings for holding screws.

The invention has been described with reference to a preferred embodiment and it will be understood that many variations and modifications thereof may be resorted to without departure from the scope of the invention as defined in the following claims.

What I claim is:—

1. A magnetic filtration system for attracting magnetizable particles com-

prising a pair of permanent magnets, each having a north and a south pole, an intermediate plate and two outer plates of soft magnetic material, said intermediate plate being disposed between identical poles of said magnets, and said outer plates being disposed adjacent to the remaining poles of said magnets and extending beyond said intermediate plate and said magnets, whereby substantially no magnetic lines of forces originate from the outer surfaces of said outer plates, while the magnetic field from said intermediate plate is very strong.

2. A system as claimed in claim 1 wherein said intermediate plate does not extend beyond said magnets.

3. A system as claimed in claim 1 wherein each of said outer plates is of generally semi-spherical shape.

4. A system as claimed in claim 1 wherein said outer plates are outwardly flared beyond said magnets.

5. A system as claimed in claim 1 wherein a perforated cover of non-magnetic material covers the free ends of said outer plates to form a collector space between said cover, said outer plates and said magnets.

6. A system as claimed in claim 1 in which the intermediate plate is substantially flush with the magnets.

7. A system as claimed in claim 1 in which the plates are of circular outline.

8. A system as particularly described with reference to Figs. 5 to 17 of the accompanying drawings.

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684,052 COMPLETE SPECIFICATION

1 SHEET

*This drawing is a reproduction of the Original on a reduced scale.*

Fig. 1

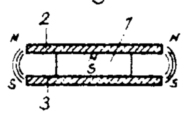

Fig. 2

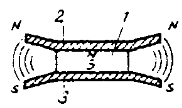

Fig. 3

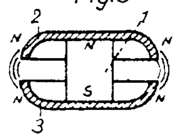

Fig. 4

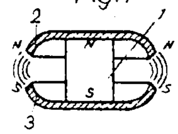

Fig. 5

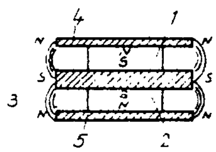

Fig. 6

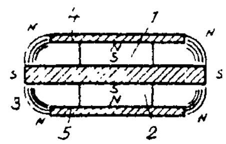

Fig. 7

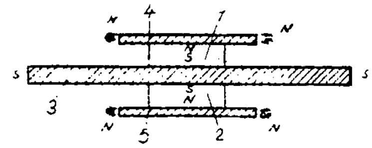

Fig. 8

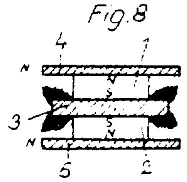

Fig. 9

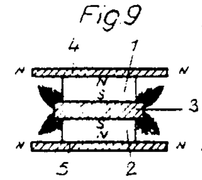

Fig. 10

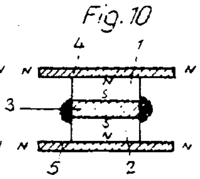

Fig. 11

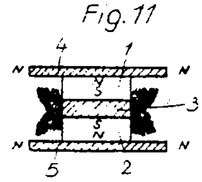

Fig. 12

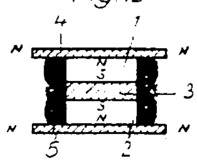

Fig. 13

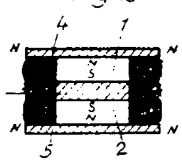

Fig. 14

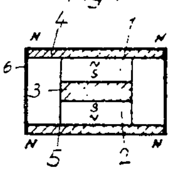

Fig. 15

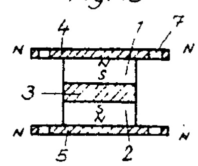

Fig. 16

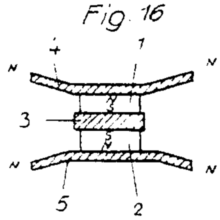

Fig. 17